3.2.2 KCRTS/RUNOFF FILES METHOD

The KCRTS/runoff files implementation of HSPF was developed as a tool that has the accuracy and versatility of HSPF but is much simpler to use and provides a framework for efficient design of onsite stormwater detention facilities. This section describes the Runoff Files Method and KCRTS software. The term *runoff files* refers to a database of continuous flows presimulated by HSPF. The KCRTS software package is a tool for using this flow database.

The Runoff Files method was developed as a hydrologic modeling tool for western King County to produce results (design flows, detention pond sizing, etc.) comparable to those obtained with the U.S. Environmental Protection Agency's HSPF model but with significantly less effort. This is achieved by providing the user with a set of 15-minute and hourly time series files of unit area land surface runoff ("runoff files") presimulated with HSPF for a range of land cover conditions and soil types within King County. The design flows are estimated and detention facilities are designed by directly accessing and manipulating the runoff file data by means of the KCRTS software.

At present, the basic capabilities of the KCRTS software include:

- Estimating time series of flows for a specified land use and location within King County
- Analyzing flow frequency and duration
- Analyzing water surface frequency and duration
- Plotting analysis results
- Sizing detention facilities.

❑ DEVELOPMENT OF THE RUNOFF FILES

To compile the runoff files, the land surface hydrologic response (represented by a time series of unit area land surface runoff) was generated by HSPF with regional parameters for a variety of land use classifications and for two long-term (50-year) hourly rainfall stations, one representing the western lowlands of King County (Sea-Tac Airport) and the other representing the eastern foothills (Landsburg). Runoff time series were generated with data from these stations for the following **eight soil/land cover types:**

- Impervious
- Till forest
- Till pasture
- Till grass
- Outwash forest
- Outwash pasture
- Outwash grass
- Wetland.

While HSPF simulates surface runoff, interflow, and groundwater flow**, only the surface and interflow components of runoff are included in the runoff files**. The large majority of developments are relatively small, and it is often not appropriate to include groundwater flows in estimates of the surface or near-surface runoff from a ***site***. For example, in designing detention facilities for a small development on till soils, the total surface or near-surface runoff from the ***site*** would usually consist of surface runoff plus interflow. Groundwater generated on the ***site*** would seep through the underlying till and may reappear (in springs or seeps) some considerable distance from the ***site***. **An interflow component of runoff is not computed for outwash soils** because there is assumed to be no low-permeability subsurface layer. Runoff files for onsite detention facility design were thus generated with the following components:

- Till soils → surface flow + interflow
- Outwash soils → surface flow
- Wetland soils → surface flow + interflow
- Impervious surfaces → surface flow.

The higher elevation eastern portions of King County have a temperature variable hydrologic cycle. **Snowmelt is not accounted for** in either the Sea-Tac or Landsburg runoff files. Additional work may be done to develop snowmelt-based runoff files for use in these areas. In the absence of additional information, analysis will be performed using the Landsburg runoff files scaled by 1.2 for all points east of the 1.2 isoline in Figure 3.2.2.A (p. 3-22).

3.2.2.1 GENERATING TIME SERIES

Most hydrologic analyses will require time series of flows for different land use conditions. For example, to size a Level 1 flow control detention facility, 2- and 10-year peaks from the facility discharge time series must be compared with 2- and 10-year peaks from the predevelopment time series. To generate a flow time series with KCRTS, the KCRTS user needs to specify the following:

1. The **rainfall region** of the county within which the project lies (i.e., determine the rainfall station—Sea-Tac or Landsburg—used in the analysis; see Figure 3.2.2.A, p. 3-22).
2. A multiplier or **regional scale factor** applied to the runoff files to account for variations in rainfall volumes between the ***project site*** and the rainfall station (see Figure 3.2.2.A, p. 3-22).
3. The **time step** to be used in the analysis:
    - Hourly — Used for detention sizing and volume analysis
    - 15 minutes — Used for peak flow analysis of conveyance systems; requires length and slope of the longest unconcentrated surface flowpath for each developed land cover type.
4. The **record type** used in the analysis:
    - Reduced 8-year record, OR
    - Historical — complete historical runoff record may be used.
5. The **amount of land** (acreage) of each soil/cover group for the subbasin under study.
6. The **percentage of impervious area** that is effectively connected to the drainage system.

Generating a new time series is simply a matter of entering the above data into KCRTS under the **"Create New Time Series" routine**. The KCRTS software will then access the appropriate runoff files (representing unit area runoff), scale those files to reflect the location of the ***project site***, scale the files again according to the area of each soil/cover group contained on the ***project site*** or subbasin in question, and then sum the scaled files to produce a time series of simulated flows from the ***site***.

❑ SELECTION OF PRECIPITATION RECORD AND REGIONAL SCALE FACTOR

As noted in the previous section, runoff files for KCRTS were developed using data from two rainfall stations, Sea-Tac Airport and Landsburg. The regions within King County to which data from the two stations apply are shown in Figure 3.2.2.A (p. 3-22). These regions were delineated such that data from Sea-Tac Airport is applied to the drier western part of the county, while data from Landsburg is applied to the wetter eastern part of the county, including developable areas in the Cascade foothills. The line separating the two regions was based on daily rainfall depths.

The *regional scale factor* is a geographically variable multiplier applied to the flow time series to account for the considerable variations in rainfall amounts, and hence runoff, within the two regions, especially in

❑ SELECTION OF RUNOFF FILE TIME STEPS AND RECORD TYPES

KCRTS runoff files are provided in both hourly and 15-minute time steps. The 15-minute time series were generated from the original historical hourly precipitation records, which were synthetically disaggregated into 15-minute time steps using 15-minute rainfall records from hydrologically similar gages.

The length of the runoff file records is periodically changed to include new data. As of January 1, 2005, the KCRTS historical record for SeaTac contains 50 years of simulated flow data. Application of the time steps and record types are shown in Table 3.2.2.A below.

TABLE 3.2.2.A SELECTION OF RUNOFF FILE TIME STEPS AND RECORD TYPES

Analysis Type	Hourly Time Steps	15-Minute Time Steps	Runoff File Record Type[1]
Flow Control Analysis			
• Existing Conditions (target release rates)	Required[2]		Reduced or Full Historical
• Developed Conditions (facility inflows)	Acceptable	Acceptable	Reduced or Full Historical
Water Quality Design Flow			
• Preceding Detention (60% 2-year rate)		Required	Reduced or Full Historical
• Following Detention (full 2-year rate)	Acceptable	Acceptable	Reduced or Full Historical
Sand Filter Volume	Acceptable	Acceptable	Reduced or Full Historical
Conveyance/Overflow Features		Required	Reduced or Full Historical
Level 2, 3 Offsite Analyses	Acceptable for volume analysis	Required for peak flow analysis	Reduced or Full Historical
Closed Depression with Severe Flooding Problem[3]	Acceptable	Acceptable	Full Historical

Notes:

(1) The runoff files do not contain a groundwater component. Therefore, KCRTS should be applied with caution where sources of groundwater express themselves as surface runoff, and the program should not be used to determine summer low-flow conditions in a stream. However, most analyses in this manual are of peak flow conditions where the groundwater contribution is usually small.

(2) Hourly time steps are used to determine predeveloped (target) release rates for all projects to provide for consistent control and protection against cumulative increases in peak flows. If 15-minute time steps were used, the predeveloped discharge rates from more quickly responding sites would be higher, and the onsite detention facilities under developed conditions would extend these rates for several hours. This extension of higher flow rates increases the chances that they will occur simultaneously with the peak flows from slower responding sites to create higher overall peaks in the downstream drainage system.

(3) See Section 3.3.6 (p. 3-49).

❑ CATEGORIZATION OF SOIL TYPES AND LAND COVER

The Runoff Files method with KCRTS currently supports eight land use classifications: till forest, till pasture, till grass, outwash forest, outwash pasture, outwash grass, wetland, and impervious. These classifications incorporate both the effects of soil type and land cover. In the SCS method, four different hydrologic soil groups are defined (A, B, C, and D) based on soil type as mapped by the SCS. The SCS also defines hydrologic response for about a dozen different land use or cover types. The SCS method therefore allows the user a considerably greater degree of flexibility in defining land cover and soil types than does KCRTS. However, the flexibility and apparent detail available with the SCS method cannot be supported on the basis of the data used to develop that method. The Runoff Files method minimizes the number of land use classifications, thereby simplifying both the analysis and review of development proposals.

KCRTS Soil Groups

Under KCRTS, three soil groups are currently defined: till, outwash, and wetland.

Till Soils

Till soils are underlain at shallow depths by relatively impermeable glacial till. The principal SCS soil group within King County classified as a till soil is the Alderwood series (SCS hydrological soil group C), which is the most common soil type throughout the western part of the county. The hydrologic response of till soils in an undeveloped, forested state is characterized by relatively slight surface runoff, substantial interflow occurring along the interface between the till soil and the underlying glacial till, and slight groundwater seepage into the glacial till.

Also included in the KCRTS till soil group are bedrock soils, primarily Beausite and Ovall soils, which are underlain by either sandstone or andesite bedrock, and a large group of alluvial soils.

Alluvial soils are found in valley bottoms. These are generally fine-grained and often have a high seasonal water table. There has been relatively little experience in calibrating the HSPF model to runoff from these soils, so in the absence of better information, these soils have been grouped as till soils. Most alluvial soils are classified by the SCS in hydrologic soil groups C and D.

Outwash Soils

Outwash soils are formed from highly permeable sands and gravels. The principal SCS soil group classified as an outwash soil is the Everett series. Where outwash soils are underlain at shallow depths (less than 5 feet) by glacial till or where outwash soils are saturated, they should be treated as till soils for the purpose of KCRTS application.

Wetland Soils

Wetland soils have a high water content, are poorly drained, and are seasonally saturated. For the purposes of applying KCRTS, wetland soils can be assumed to coincide with wetlands as defined in the critical areas code (KCC 21A.24).

The approximate correspondence between SCS soil types and the appropriate KCRTS soil group is given in Table 3.2.2.B (p. 3-25). If the soils underlying a proposed project have not been mapped, or if existing soils maps are in error or not of sufficient resolution, then a soils analysis and report shall be prepared and stamped by a ***civil engineer*** with expertise in soils to verify underlying soil conditions.

TABLE 3.2.2.B EQUIVALENCE BETWEEN SCS SOIL TYPES AND KCRTS SOIL TYPES

SCS Soil Type	SCS Hydrologic Soil Group	KCRTS Soil Group	Notes
Alderwood (AgB, AgC, AgD)	C	Till	
Arents, Alderwood Material (AmB, AmC)	C	Till	
Arents, Everett Material (An)	B	Outwash	1
Beausite (BeC, BeD, BeF)	C	Till	2
Bellingham (Bh)	D	Till	3
Briscot (Br)	D	Till	3
Buckley (Bu)	D	Till	4
Earlmont (Ea)	D	Till	3
Edgewick (Ed)	C	Till	3
Everett (EvB, EvC, EvD, EwC)	A/B	Outwash	1
Indianola (InC, InA, InD)	A	Outwash	1
Kitsap (KpB, KpC, KpD)	C	Till	
Klaus (KsC)	C	Outwash	1
Neilton (NeC)	A	Outwash	1
Newberg (Ng)	B	Till	3
Nooksack (Nk)	C	Till	3
Norma (No)	D	Till	3
Orcas (Or)	D	Wetland	
Oridia (Os)	D	Till	3
Ovall (OvC, OvD, OvF)	C	Till	2
Pilchuck (Pc)	C	Till	3
Puget (Pu)	D	Till	3
Puyallup (Py)	B	Till	3
Ragnar (RaC, RaD, RaC, RaE)	B	Outwash	1
Renton (Re)	D	Till	3
Salal (Sa)	C	Till	3
Sammamish (Sh)	D	Till	3
Seattle (Sk)	D	Wetland	
Shalcar (Sm)	D	Till	3
Si (Sn)	C	Till	3
Snohomish (So, Sr)	D	Till	3
Sultan (Su)	C	Till	3
Tukwila (Tu)	D	Till	3
Woodinville (Wo)	D	Till	3

Notes:

1. Where outwash soils are saturated or underlain at shallow depth (<5 feet) by glacial till, they should be treated as till soils.
2. These are bedrock soils, but calibration of HSPF by King County DNRP shows bedrock soils to have similar hydrologic response to till soils.
3. These are alluvial soils, some of which are underlain by glacial till or have a seasonally high water table. In the absence of detailed study, these soils should be treated as till soils.
4. Buckley soils are formed on the low-permeability Osceola mudflow. Hydrologic response is assumed to be similar to that of till soils.

KCRTS Land Cover Types

KCRTS supports four land cover types: forest, pasture, grass, and impervious. These cover types shall be applied in accordance with Core Requirement #3 and as specified in Table 3.2.2.C. Predevelopment land cover types are determined by whether the project is in a Basic or Conservation Flow Control Area and whether the area in question is a target surface, as defined in Section 1.2.3.1. Target surfaces within Basic Flow Control Areas and non-target surfaces are modeled as ***existing site conditions***; for target surfaces in Conservation Flow Control Areas the predeveloped condition is assumed to be ***historic site conditions***.

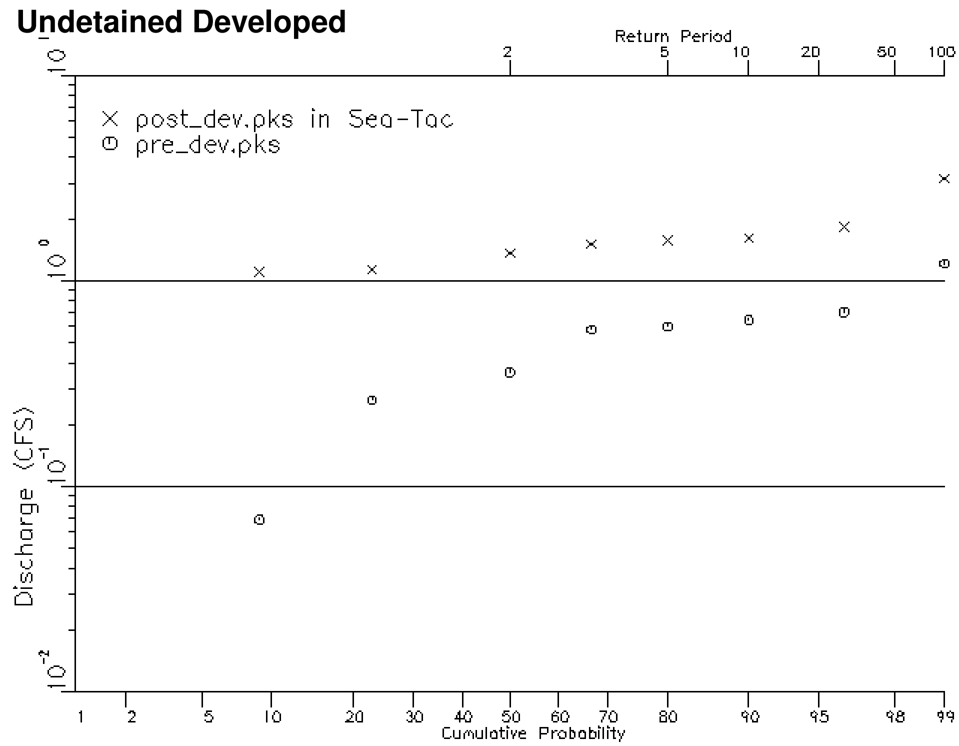
TABLE 3.2.2.C KCRTS COVER GROUPS AND AREAS OF APPLICATION

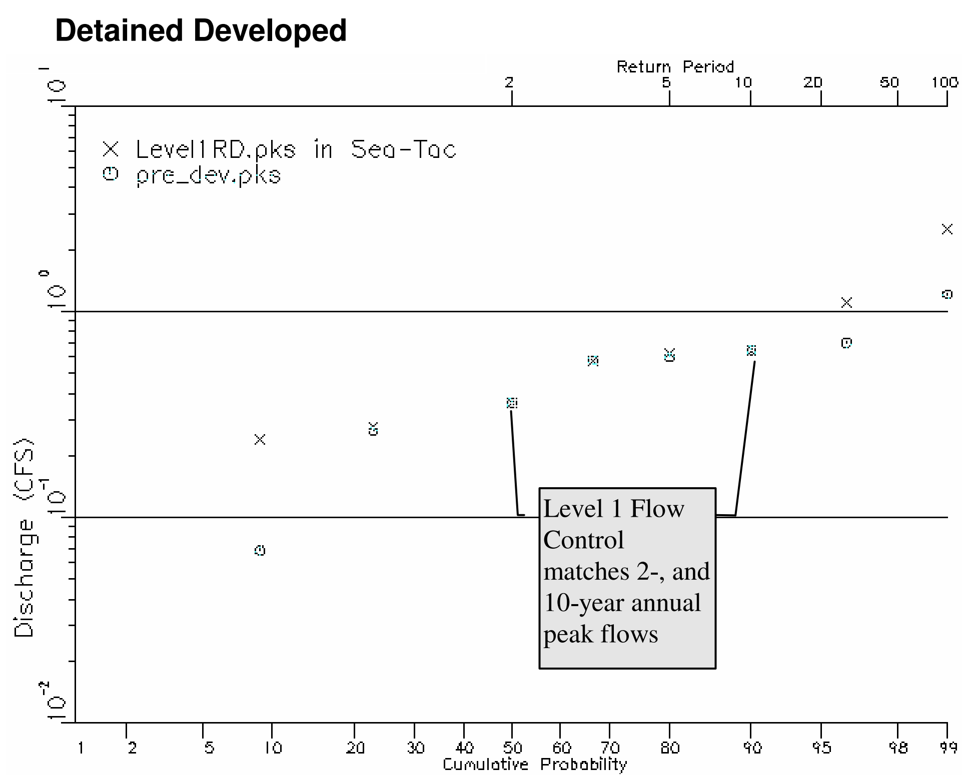
KCRTS Cover Group	APPLICATION	
	Predevelopment	**Post-Development**
Forest	All forest/shrub cover, irrespective of age.	All permanent (e.g., protected by covenant or CAO designation) onsite forest/shrub cover, irrespective of age, planted at densities sufficient to ensure 80%+ canopy cover within 5 years.
Pasture	All grassland, pasture land, lawns, and cultivated or cleared areas, except for lawns in redevelopment areas with predevelopment densities in excess of 4 DU/GA.	Unprotected forest in rural residential development shall be considered half pasture, half grass. Pasture areas to be retained on large rural residential lots (10 acres or greater) may be modeled as half pasture, half grass.
Grass	Lawns in redevelopment areas with predevelopment densities in excess of 4 DU/GA.	All post-development grassland and landscaping and all onsite forested land not protected by covenant or SASA designation (except in rural areas as noted above). Pervious areas that include underdrain collection systems (e.g., grass or synthetic turf sport fields) should be modeled as 75% grass and 25% effective impervious.
Wetland	All delineated wetland areas (except cultivated/drained farmland).	All delineated wetland areas (except cultivated/drained farmland).
Impervious(1)	All impervious surfaces, including heavily compacted gravel and dirt roads, parking areas, etc., and open water bodies (ponds and lakes).	All impervious surfaces, including compacted gravel and dirt roads, parking areas, etc., and open water bodies, including onsite detention and water quality ponds.(2)

(1) Impervious acreage used in KCRTS computations should be the **effective impervious area (EIA)**. This is the gross impervious area multiplied by the effective impervious fraction (see Table 3.2.2.E, p. 3-29). Non-effective impervious areas are considered the same as the surrounding pervious land cover.

(2) To avoid iterations in the facility sizing process, the "assumed size" of the facility need only be within 80% of the final facility size when modeling its contribution of runoff from direct rainfall.

FIGURE 3.2.2.B EXAMPLE FLOW FREQUENCY ANALYSIS





Flow frequency information is derived from the time series flow file by plotting the peak annual events in the runoff file and calculating runoff frequencies using a Log Pearson distribution. The **return periods calculated in KCRTS** are: 100-year, 25-year, 10-year, 5-year, 3-year, 2-year, 1.3-year and 1.1-year. The 50-year return event is an interpolated value using the 25-year and 100-year return events

❑ FLOW DURATION ANALYSIS

Flow durations are important because they show the change in duration of all high flows rather than the change in frequency of the peak annual flows. Channel scour and bank erosion rates rise proportionally with increases in flow durations. Flow duration analysis can only be conducted with continuous flow models or from gage records.

A *flow duration curve* is simply a plot of flow rate against the percentage of time that the flow rate is exceeded. In a continuous flow model, the *percent exceedance* of a given flow is determined by counting the number of time steps during which that flow is equaled or exceeded and dividing that number by the total number of time steps in the simulation period. Flow duration curves are usually plotted with a linear flow scale versus a log scale of percent exceedance. The log scale for exceedance percentage is used because geomorphically significant flows (flows capable of moving sediment) and flows that exceed the 2-year flow typically occur less than one percent of the total time.

Durations for Flow Control Standards

The **Level 2 flow control standard** described in Section 3.1.2 (p. 3-5) requires matching predevelopment and post-development flow duration curves for all flows greater than one-half of the 2-year flow up to the 50-year flow.

KCRTS provides flow duration curves for either flows or water levels. To support facility design, KCRTS will create a *"target" predevelopment duration curve* for the range of flows being analyzed. To simplify design, **brief excursions**[1] above the target predevelopment duration curve are allowed for flows greater than 50 percent of the predevelopment 2-year. These excursions shall not increase the discharge by more than 10% at any duration level and must be strictly below the target curve at the low end of the range of control (i.e., 50% of the 2-year peak flow). This allows efficient design using only two orifices for most applications; see the *KCRTS Computer Software Reference Manual* for a detailed example. An example of a flow duration analysis is shown in Figure 3.2.2.C (p. 3-33).

The **Level 3 flow control standard** matches predevelopment and post-development flow durations over the same range of predevelopment flows as the Level 2 flow control standard. In addition, the 100-year post-development peak flow must be contained within the facility and controlled to predevelopment levels. This standard provides additional storage volume over the Level 2 flow control facility, which substantially mitigates the impacts of increased volumes of surface runoff on downstream, volume-sensitive flooding problems.

The **Level 1 flow control standard** does not require flow duration analysis because it addresses peak flows only.

[1] Brief excursions may not result in more than 50% of the target duration curve being exceeded.